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# Geographic Variation in Declining Ischemic Heart Disease Mortality in the United States, 1968-1978

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16. ABSTRACT

Despite the well-known geographic pattern for ischemic heart disease (IHD) mortality, studies of the decline in IHD have not provided a comprehensive examination of its spatial component. In this study, we computed and mapped mean rates and percent change in IHD mortality for whites, ages 35-74, during the eighth revision (1968 1978) of the International Classification of Diseases (ICD). Visual evidence of clustering and markedly different spatial patterns were found for mean rate and percent change among the State Economic Areas (SEA) of the U.S. Spatial patterns of change varied by gender.

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# GEOGRAPHIC VARIATION IN DECLINING ISCHEMIC HEART DISEASE MORTALITY IN THE UNITED STATES, 1968–1978

## I. RATES AND CHANGE, WHITES AGED 35–74 YEARS

WAYNE B. DAVIS,[1] CARL G. HAYES,[1] MARILYN KNOWLES,[1] WILSON B. RIGGAN,[2] JOHN VAN BRUGGEN,[3a] AND H. A. TYROLER[1]

**Davis, W. B., C. G. Hayes, M. Knowles, W. B. Riggan, J. Van Bruggen, and H. A. Tyroler (Dept. of Epidemiology, School of Public Health, U. of North Carolina, Chapel Hill, NC 27514). Geographic variation in declining ischemic heart disease mortality in the United States, 1968–1978. I. Rates and change, whites aged 35–74 years. *Am J Epidemiol* 1985;122:657–72.**

**Despite the well known geographic pattern for heart disease mortality, studies of the decline in ischemic heart disease have not provided a comprehensive examination of its spatial component. In this study, the authors computed and mapped mean rates and per cent change in ischemic heart disease mortality for whites aged 35–74 years, for the period of the Eighth Revision (1968–1978) of the *International Classification of Diseases*. Visual evidence of clustering and markedly different spatial patterns were found for mean rate and per cent change among the state economic areas of the United States.**

**ischemic heart disease; mortality**

### THE DECLINE PHENOMENON

The current dramatic decline in ischemic heart disease mortality is widely reported in the cardiovascular and epidemiologic literature and is well established for diverse geographic areas (1–3) and for the four major race-sex groups (4, 5). The reality of the decline is supported by the concurrent decline in all-cause mortality, the lack of evidence of a diagnostic shift to any other cardiovascular component, the lack of evidence of a shift of the required magnitude to less specific entities (6), and the length and extent of the decline itself. The consensus among researchers who have published to date is that the decline was in effect in 1968 and has been present for the subsequent 10 years of the Eighth Revision of the *International Classification of Diseases* (ICD). Conclusive evidence to indicate whether these changes are primarily due to declining incidence or to changes in case fatality (or to both) is not available. Various investigators have provided speculation on both sides; the limited data available are contradictory (7, 8). Research published to date has provided no comprehensive investigation of the spatial variation of the decline for a large geographic area. A geographic focus is important for several reasons, including the current lack of information on the origin of the decline (4, 9, 10), the well documented spatial variation in the rates of ischemic heart disease

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mortality (2, 3, 11, 12), the hypothesized potential for geographic variation in possible components of the decline phenomenon, particularly cardiovascular risk factors (e.g., smoking, plasma cholesterol, high blood pressure), and for variation in the availability and quality of medical care and health services.

This report describes the impact of the decline in ischemic heart disease and its spatial variation on mortality rates in whites. Similar analyses are under way which examine patterns for nonwhites, comparisons between genders, and age-specific trends. Analyses of the geographic correlates of the decline phenomenon including characteristics of the physical environment, occupational and socioeconomic factors, comparison of urban and rural residence, and medical care and health services availability will follow these basic descriptive investigations.

## Materials and methods

### *Geographic focus*

Examining the spatial variation of any phenomenon requires difficult choices regarding the level of aggregation for the analysis. Achievement of the research objective will vary with the success of this decision and the appropriateness of the level of aggregation chosen. This choice must be made within a conceptual framework, neither selected by convenience nor defined by the data. This study examined the decline phenomenon at both the national and state economic area levels. Furthermore, the state economic area analysis presents results for the entire United States and for an area of the southeastern United States.

The state economic area, unlike the county or the state, is not only based on political or historical circumstances but is also defined by the size and composition of its population and the amount and type of economic and agricultural activity within its borders (13). These factors were measured, and the state economic areas were constructed to provide adequate population size and relative social and economic homogeneity within their borders. A state economic area is either a single metropolitan county or an aggregation of nonmetropolitan counties which follow county and state boundaries, neither breaking up individual counties nor crossing state lines. State economic areas are appropriate for cardiovascular research given the evidence of higher rates in urban areas (11, 14, 15), higher rates among rural residents of counties undergoing modernization/urbanization (16), potential importance of the socioeconomic, occupational, and physical environment, and of medical care and health services (17), the availability of which varies spatially.

### *Other study characteristics*

The primary focus of this report is ischemic heart disease. Four categories of death, however, were analyzed: all causes, ischemic heart disease (ICD-8 410–413), acute myocardial infarction (ICD-8 410), and chronic ischemic heart disease (ICD-8 412). Component analysis of ischemic heart disease could provide clues to the changing situation in heart disease mortality.

This investigation was restricted to the period covered by the Eighth Revision of the *International Classification of Diseases* (1968–1978). This restricted time period coincides with the period of declining rates most often reported in the literature and eliminates the problem of comparability of death certificate coding across revisions of the ICD.

This study examined mortality for white males and females 35–74 years of age. Mortality data were acquired from the National Center for Health Statistics as death records on magnetic tape. These were summarized by place of residence, year of death, sex, and five-year age groups for each of the above cause-of-death categories.

Population counts were obtained from the Census Bureau for 1960, 1970, and

1980. Linear interpolation was used to produce annual midyear estimates.

### *Analysis approach*

Age-, sex-, and cause-specific death rates are calculated for five-year age groups on an annual basis for the 11 years of the study period. The annual age-specific rates are age-adjusted to the 1970 US population, using the direct method to provide a single, annual, sex- and cause-specific mortality rate for those 35–74 years of age. Rates are computed for the United States and separately for each state economic area. The 11 annual rates for each state economic area constitute the raw data points for computation of a linear regression equation which represents the best estimate of the underlying linear trend of mortality for the time period. The beta coefficient for the effect of time is the estimated average annual absolute change in the mortality rate based on all 11 data points. Employing the beta coefficients for time and the constant term from the model equation, we computed the initial (1968) and terminal (1978) fitted annual mortality rates (MR), and from these we calculated the per cent change for the study period in the following manner:

$$((MR1978 - MR1968)/MR1968) \times 100.$$

To permit comparisons of change with the magnitude of the rate, we determined the mean rate of mortality for the time period, again relying on the regression equation parameters. Per cent change and mean rate are calculated for each gender, each cause of death, and each state economic area. The per cent change values, representing the temporal trend, and the mean rates are mapped to examine their spatial distribution. The map categories are determined by dividing the ranked state economic areas into quintiles, combining the middle three quintiles into a single mapping category, and constructing the map by means of these three categories. This study used the statistical and cartographic capabilities of the Statistical Analysis System (18).

TABLE 1

*Mortality rates and per cent change, United States, 1968–1978, whites aged 35–74 years (per 100,000 population)*

| Cause* | Rate 1968† | Rate 1978† | Mean rate† | % change† |
|---|---|---|---|---|
| | | *Males* | | |
| All | 1,729.3 | 1,410.0 | 1,569.7 | −18.5 |
| IHD | 706.6 | 523.7 | 615.2 | −25.9 |
| AMI | 493.0 | 324.1 | 408.5 | −34.3 |
| CIHD | 208.1 | 194.9 | 201.5 | −6.3 |
| | | *Females* | | |
| All | 859.6 | 705.1 | 782.4 | −18.0 |
| IHD | 255.3 | 178.3 | 216.8 | −30.2 |
| AMI | 156.7 | 101.3 | 129.9 | −35.4 |
| CIHD | 96.7 | 75.7 | 86.2 | −21.7 |

* Causes based on coding by the 8th Revision of the ICD: All, all causes; IHD, ischemic heart disease (410–413); AMI, acute myocardial infarction (410); CIHD, chronic ischemic heart disease (412).

† Rates and per cent change are estimated from linear regression equation parameters. Per cent change = ((rate 1978 − rate 1968)/rate 1968) × 100.

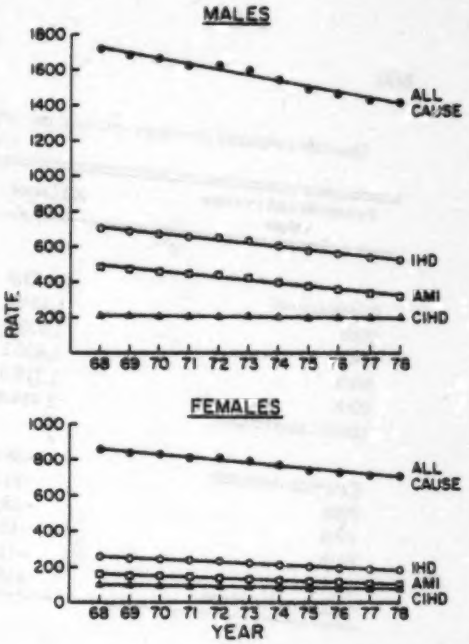


FIGURE 1. Actual and fitted mortality rates. All causes, ischemic heart disease (IHD), acute myocardial infarction (AMI), chronic ischemic heart disease (CIHD), US white males and females aged 35–74 years, 1968–1978.

TABLE 2

*Quintile cutpoints for mean rate and per cent change, US state economic areas, 1968–1978, white males aged 35–74 years*

| Percentile and extreme values | All causes | Ischemic heart disease | Acute myocardial infarction | Chronic ischemic heart disease |
|---|---|---|---|---|
| | | *Mean rate (per 100,000 population)* | | |
| 0 (minimum) | 1,179.9 | 390.0 | 232.8 | 56.4 |
| 20th | 1,434.4 | 527.7 | 367.2 | 117.8 |
| 40th | 1,532.0 | 579.5 | 417.2 | 143.8 |
| 60th | 1,620.1 | 639.0 | 465.6 | 168.4 |
| 80th | 1,718.3 | 685.2 | 512.3 | 202.5 |
| 100th (maximum) | 2,414.8 | 998.7 | 781.3 | 505.9 |
| | | | *% change* | |
| Extreme decrease | −35.1 | −56.4 | −72.5 | −55.3 |
| 20th | −21.5 | −31.6 | −42.4 | −18.6 |
| 40th | −18.3 | −26.8 | −35.6 | −5.7 |
| 60th | −15.4 | −22.4 | −30.2 | +5.7 |
| 80th | −11.2 | −17.4 | −22.9 | +22.8 |
| Extreme increase | +15.7 | +10.2 | +4.5 | +186.4 |

TABLE 3

*Quintile cutpoints for mean rate and per cent change, US state economic areas, 1968–1978, white females aged 35–74 years*

| Percentile and extreme values | All causes | Ischemic heart disease | Acute myocardial infarction | Chronic ischemic heart disease |
|---|---|---|---|---|
| | | *Mean rate (per 100,000 population)* | | |
| 0 (minimum) | 585.9 | 135.4 | 68.4 | 29.0 |
| 20th | 701.9 | 171.0 | 109.4 | 53.0 |
| 40th | 743.7 | 194.3 | 125.4 | 64.7 |
| 60th | 782.4 | 216.6 | 139.0 | 76.2 |
| 80th | 826.6 | 243.7 | 159.3 | 91.6 |
| 100th (maximum) | 1,060.4 | 355.5 | 261.5 | 214.4 |
| | | | *% change* | |
| Extreme decrease | −35.3 | −74.4 | −74.3 | −85.0 |
| 20th | −22.0 | −36.2 | −43.4 | −34.5 |
| 40th | −18.4 | −30.6 | −37.1 | −23.9 |
| 60th | −14.5 | −25.0 | −29.9 | −12.7 |
| 80th | −9.8 | −18.3 | −21.6 | +3.8 |
| Extreme increase | +14.3 | +25.3 | +27.0 | +212.5 |

## RESULTS

### *National rates and change*

For the United States, all four categories of death declined from 1968–1978 for both sexes (table 1, figure 1). The per cent change values for males and females are approximately equal for all causes (−18 per cent) and for acute myocardial infarction (−35 per cent), while declines for females exceeded those for males for total ischemic heart disease (females: −30 per cent; males: −26 per cent) and chronic ischemic heart disease (females: −22 per cent; males: −6 per cent). For both sexes, and especially for men, acute myocardial mortality declined more than chronic ischemic heart disease. The decline in chronic ischemic heart disease was modest for males (table 1).

### *State economic areas*

*All areas.* At the state economic area level, declines in mortality are present for the study period for each cause and both

sexes. When the state economic areas are rank-ordered by their per cent change values, there is little variation across the middle three quintiles (central 60 per cent of areas). The magnitude of declines for state economic areas in the middle three quintiles is virtually identical for males and females for all-cause, ischemic heart disease, and acute myocardial infarction. Chronic ischemic heart disease per cent change values differ somewhat between males and females and are more dissimilar from the other three causes (tables 2 and 3). The range of per cent change values in the middle three quintiles for both males and females is from −10 per cent to −22 per cent for all-cause mortality, from −17 per cent to −36 per cent for ischemic heart disease, and from −22 per cent to −43 per cent for acute myocardial infarction. The per cent change values for chronic ischemic heart disease range from +22 per cent to −19 per cent for males and from +4 per cent to −35 per cent for females. For some state economic areas for each cause and sex group, the mortality rate increased for the study period; this was most pronounced for chronic ischemic heart disease. An examination of the actual distribution of per cent change values reveals very few areas with increasing rates for all-cause, ischemic heart disease, and acute myocardial infarction mortality. For the 509 state economic areas examined, increasing per cent change values were present in five or fewer areas (1.0 per cent or less) for males and in 13 or fewer areas (2.5 per cent or less) for females for these three causes. (For mapping per cent change for ischemic heart disease, we will refer to all categories as declines since so few areas had increasing rates.) For chronic ischemic heart disease, male rates increased in half (250 or 49.1 per cent) of the 509 areas, while female rates increased in nearly one fourth of these areas (118 or 23.2 per cent).

Maps of mean rates and per cent change for state economic areas for ischemic heart disease for males and females are presented in figures 2–5. Mean rates demonstrate a marked west-to-east gradient (figures 2 and 4). On both maps, state economic areas in a given rate category appear to cluster. Areas of high rates are noted in the Southeast and in the Central and North Appalachians. The former is more extensive for males, the latter for females.

The per cent change maps (figures 3 and 5) also provide visual evidence of clustering among those state economic areas with similar change values. The patterns of change differ from the rate patterns, and the male and female per cent change maps are generally more dissimilar than the corresponding rate maps, although in particular areas they agree. A visual comparison between mean rate and per cent change maps reveals no consistent trend. Visual comparison of the Central Appalachian area indicates that a high mean rate is associated with a small per cent decline, while in the Southeast, high rate areas correspond to areas of large per cent decrease; this is true for both males and females.

Statistical analysis of the rate with the per cent change is presented in table 4. Spearman rank-order correlation coefficients are computed for the mean rate with the per cent change for state economic area by gender. For both males and females, acute myocardial infarction is significantly negatively correlated, indicating that the higher the mean rate the smaller the decline for the time period. For female all-cause mortality, there is a significant positive correlation between mean rate and per cent change, implying that the higher the rate the greater the decline in rates for the period. No other correlations are statistically significantly different from zero.

Spearman rank-order correlation coefficients for male mean rate with female mean rate and male per cent change with female per cent change, by state economic area, are presented in table 5. All correlations are positive and significant (all $p$ values $< 0.0001$), but the mean rate coefficients are higher than those for per cent change.

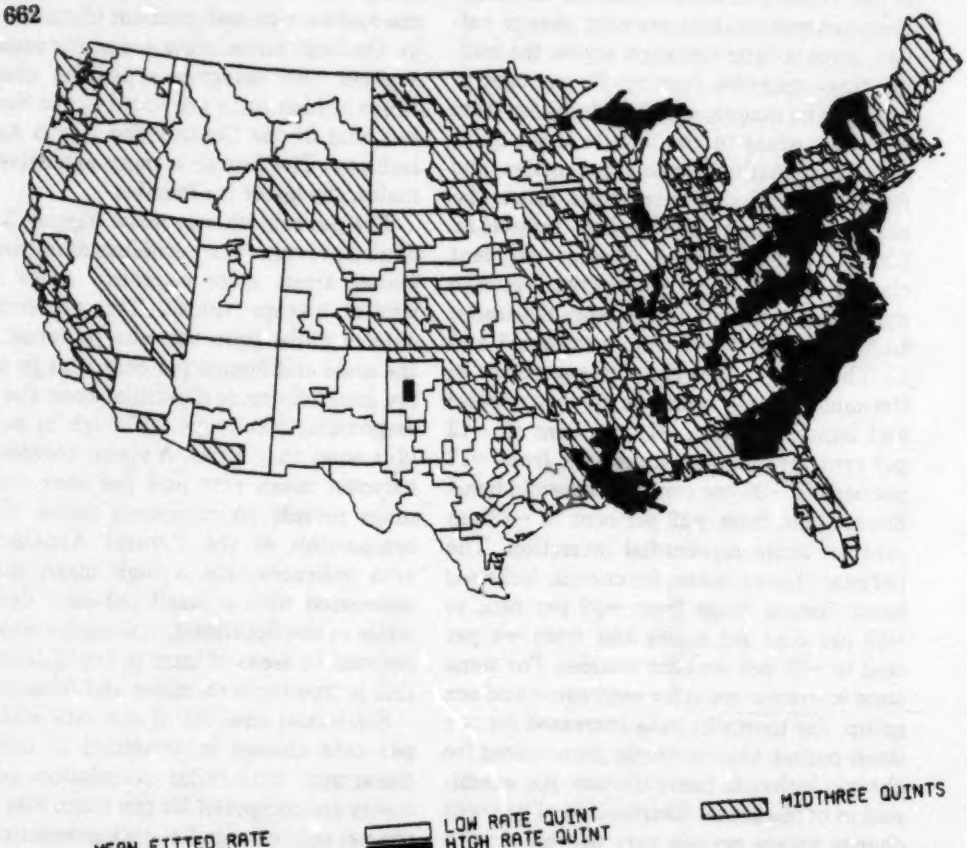


FIGURE 2. Mean fitted mortality rates, 1968–1978, ischemic heart disease, white males, aged 35–74 years, United States, by state economic area.

While this difference confirms the cartographic suggestion of high correspondence for the rate maps and reduced similarity for the male and female change maps, a lower change coefficient must be attributed, in part, to the use of two estimates in the per cent change calculation, thereby increasing the variance.

*The southeastern region.* The Southeast provides an appropriate demonstration of the utility of moving to a regional focus from the national analysis. Georgia, South Carolina, and North Carolina constitute a three-state area within the southeastern United States that has historically experienced extreme gradients of coronary heart disease mortality and traditionally included a large proportion of the highest rate areas of the country (11). State economic area maps for ischemic heart disease mortality, for white males only, are provided in figures 6–9. The spatial patterns of fitted rates for 1968, 1973, and 1978 (the initial, middle, and final years of the study period) are presented in figures 6–8, while the per cent change pattern for the entire period is shown in figure 9. The 1968 rate map (figure 6) emphasizes the extensive cluster of high rate areas that includes approximately half of the total area of Georgia, South Carolina, and North Carolina (specifically, the southern half of Georgia, all of South Carolina, and a portion of southeastern North Carolina). The rate map series (fig-

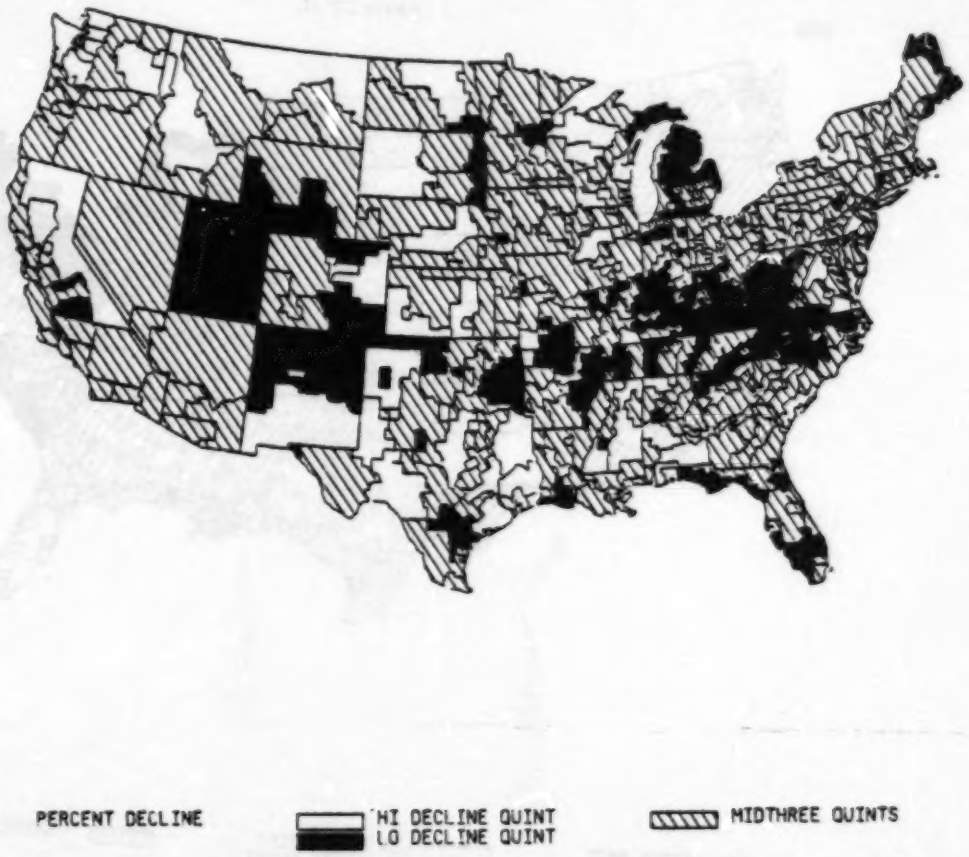


FIGURE 3. Estimated per cent change in ischemic heart disease mortality rates, 1968–1978, white males aged 35–74 years, United States, by state economic area.

ures 6–8) demonstrates the improvement of the coastal areas of Georgia and South Carolina (relative to the national situation) and the movement of central North Carolina into the highest rate quintile. The per cent change map (figure 9) reveals marked clustering of the lower and middle three quintiles. Additionally, the areas of low per cent decline on the change map generally correspond to areas outside the high rate cluster on the 1968 rate map. Conversely, those areas of moderate-to-high decline are found in the high rate quintile area of the 1968 rate map. The specifics of coastal area rate improvement and the apparent association of lower rate areas with low decline areas could not be easily determined from the national maps but are clearly revealed in this regional examination.

## DISCUSSION

The first report of declining rates of heart disease mortality at the national level can be attributed to Walker (19), who pinpointed 1963 as the peak year in the trend of increasing heart disease rates and suggested that every year from 1964 to 1969 showed lower rates of heart disease mortality, compared with those of 1963. In general, the post-1963 trend was one of ever decreasing rates.

Subsequent analyses by Gordon and Thom (4) and Cooper et al. (5) further examined national mortality rates. Gordon

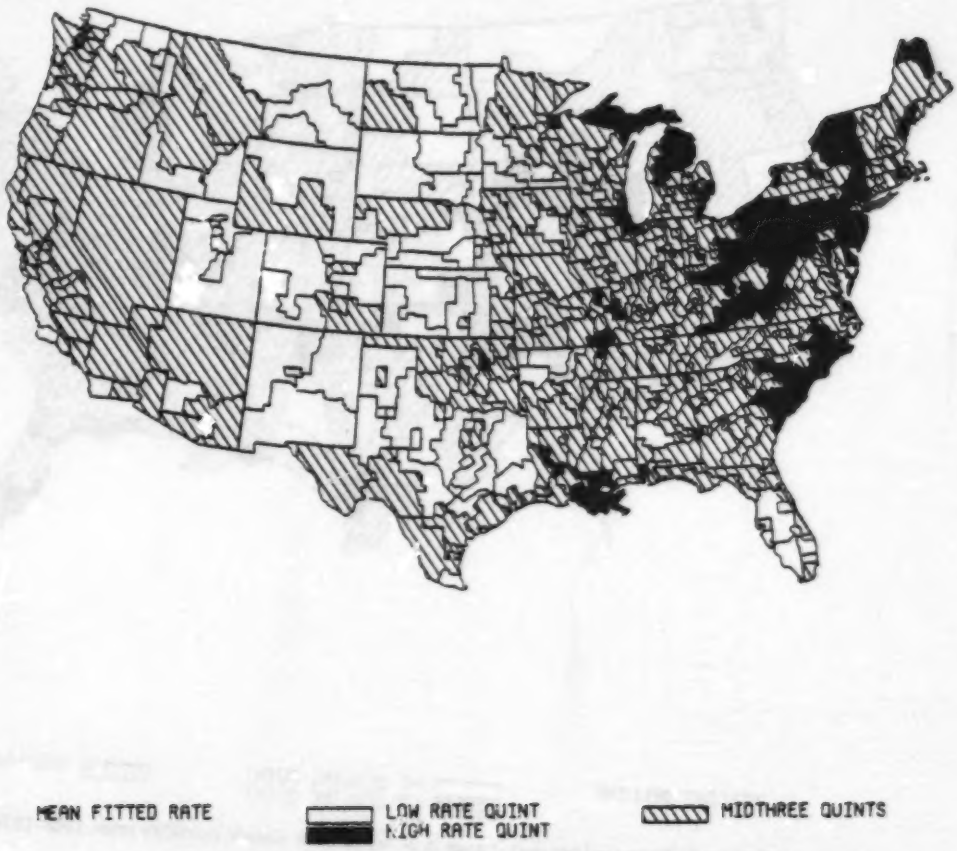


FIGURE 4. Mean fitted mortality rates, 1968–1978, ischemic heart disease, white females aged 35–74 years, United States, by state economic area.

and Thom focused on the period of the Eighth Revision of the ICD (1968–1978) and suggested that race-sex trends for declining heart disease mortality were very similar and "in flat contradiction to all previous experience where trends by race and sex differed radically." They concluded that "the per cent decrease varied relatively little from one group to another." The data they presented, however, show consistently greater reduction for nonwhite females and better overall changes for nonwhites than for whites.

Cooper et al. (5) used annual age-adjusted heart disease mortality rates for 1940–1975 to compute Kendall's rank correlation coefficients (tau) for each race-gender group for each revision of the ICD (fifth through eighth). For white females, significant mortality declines occurred from 1958–1975; for the remaining three groups (white males, and nonwhite males and females), significant declines in mortality occurred only during the most recent revision (1968–1975). Cooper et al. view the recent period (1968–1975) as "a uniform and unprecedented departure from the previous trends." All four groups showed a "continued statistically significant improvement in death rates." The rate declines for 1968–1975 showed female rate declines exceeding those of males for both races (white males: −19 per cent; white females: −24 per cent; nonwhite males: −20 per cent; nonwhite females: −35 per cent).

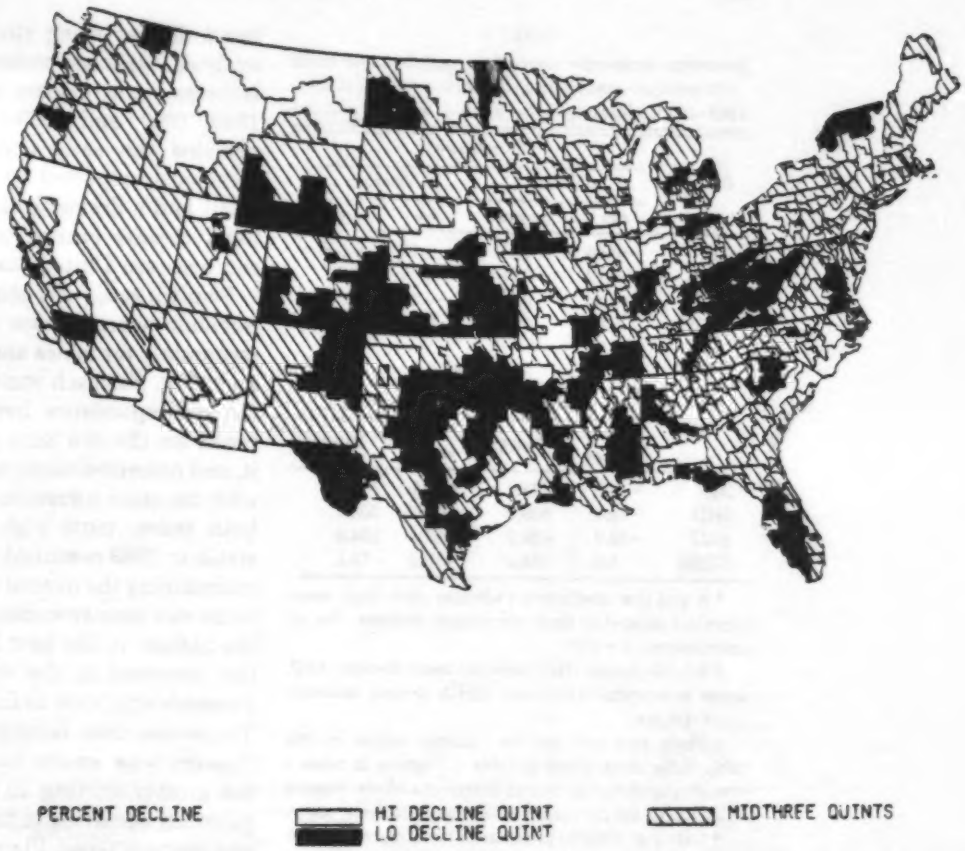


FIGURE 5. Estimated per cent change in ischemic heart disease mortality rates, 1968–1978, white females aged 35–74 years, United States, by state economic area.

Our analysis of national rates found declining mortality for both sexes, for all causes and for three specific causes, including ischemic heart disease. We found that the per cent decline in heart disease mortality for women exceeded that for men, as did Cooper et al. (5), and this favorable female differential was even greater for the chronic component of total ischemic heart disease. There was no sex difference in per cent decline for all causes, however, or in the acute portion of total heart disease.

While Walker demonstrated the appearance of the decline at the national level, Hechter and Borhani (1) must be credited with the first reporting of heart disease declines in their analysis of arteriosclerotic heart disease, including coronary disease, for the states of the continental United States, with special emphasis on California. Hechter and Borhani found that heart disease mortality declined 12 per cent in California and 4 per cent in Utah for 1950–1960, while rates for New York were stable for the period. The investigation by Hechter and Borhani provides evidence that the decline in coronary heart disease was actually beginning in the 1950s for some areas of the country, a situation masked by analysis of rates only at the national level.

Stallones (20), Feinleib et al. (21), and Kimm et al. (3) have more recently studied

TABLE 4

*Spearman rank-order correlation coefficients for mean rate with per cent change, US state economic areas, 1968–1978, whites aged 35–74 years, by cause and sex*

| Cause† | Correlations* | | | |
|---|---|---|---|---|
| | Males | | Females | |
| | rho | p value | rho | p value |
| All | −0.06 | 0.17 | 0.15 | 0.0005 |
| IHD | −0.12 | 0.00 | 0.02 | 0.68 |
| AMI | −0.35 | 0.0001 | −0.22 | 0.0001 |
| CIHD | 0.07 | 0.11 | 0.05 | 0.26 |

| | Means‡ | | | |
|---|---|---|---|---|
| | Males | | Females | |
| | % change | Rate§ | % change | Rate§ |
| All | −16.3 | 1,584.2 | −15.9 | 763.8 |
| IHD | −24.4 | 609.9 | −27.2 | 208.7 |
| AMI | −32.7 | 439.9 | −32.4 | 134.0 |
| CIHD | 5.4 | 164.6 | −13.8 | 73.1 |

* A positive coefficient indicates that high mean rates are related to large percentage declines. For all calculations, $n = 509$.

† All, all causes; IHD, ischemic heart disease; AMI, acute myocardial infarction; CIHD, chronic ischemic heart disease.

‡ Mean rate and per cent change values in this table differ from those in table 1. Figures in table 1 are calculated for the United States as a whole. Figures in this table are the means of the state economic areas.

§ Rate per 100,000 population from regression parameters.

TABLE 5

*Spearman rank-order correlation coefficients for male mean rate with female mean rate and male per cent change with female per cent change, US state economic areas, 1968–1978, whites aged 35–74 years*

| Cause† | Correlations* | | | |
|---|---|---|---|---|
| | Mean rate | | % change | |
| | rho | p value | rho | p value |
| All | 0.68 | <0.0001 | 0.39 | <0.0001 |
| IHD | 0.88 | <0.0001 | 0.41 | <0.0001 |
| AMI | 0.89 | <0.0001 | 0.55 | <0.0001 |
| CIHD | 0.88 | <0.0001 | 0.52 | <0.0001 |

* For all calculations, $n = 509$.

† All, all causes; IHD, ischemic heart disease; AMI, acute myocardial infarction; CIHD, chronic ischemic heart disease.

heart disease using states as the unit of analysis. Stallones presented maps of state ischemic heart disease mortality rates for 1950, 1960, and 1969–1971. These maps revealed the early decline in California (previously reported by Hechter and Borhani) and a dramatic shift of the national heart disease burden to the eastern and southeastern United States.

Feinleib et al. (21) computed quartiles of ischemic heart disease mortality by state (separately for males and females) for 1969 and 1978. For each state, they determined the correspondence between the quartile ranks for the two time points, categorized it, and presented maps of the United States with the state correspondence pattern. For both sexes, most high and low quartile states in 1969 remained so in 1978, thereby maintaining the overall pattern. For males, there was greater evidence of shifting from the highest to the next lower quartile, and this occurred in the eastern states from Pennsylvania west to Indiana and south to Tennessee. For females, there were few changes between the highest two quartiles, but greater shifting among the lower two, generally occurring in the Rocky Mountain and western Great Plains states.

Kimm et al. (3) computed mortality rates for four southeastern states (Virginia, North Carolina, South Carolina, and Georgia) and three others (New York, Utah, and California), by race and sex, for ages 30–74 years, for ischemic heart disease for 1950–1976. Their results showed that ischemic heart disease mortality rates in the southeastern states increased until 1968 and decreased thereafter for all four race-sex groups. For the three comparison states, identified by Hechter and Borhani (1) as having declining or stable mortality rates, different trends were found. In New York and Utah, the rates from 1950–1967 were essentially stable for white males and decreasing for other groups. For California, the rates from 1950–1967 for all groups were declining, especially for whites. For 1968 onward, all four groups in these three

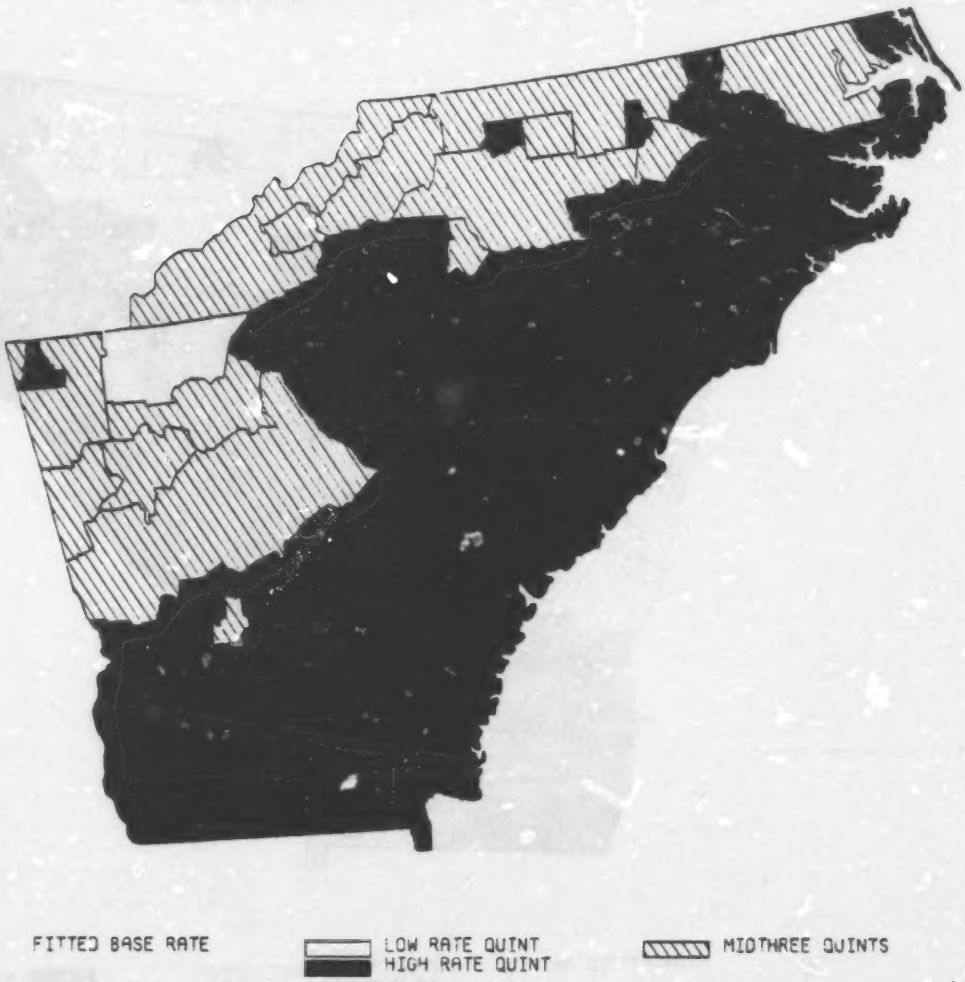


FIGURE 6. Fitted mortality rates, 1968, ischemic heart disease, white males aged 35–74 years, Southeast, by state economic area.

states showed strong declines. The authors concluded that there was good evidence of differential timing in the onset of declining mortality for ischemic heart disease and that this difference had both a geographic and demographic component among states.

Our heart disease rate maps of the United States using state economic areas (figures 2 and 4) are similar to the state maps presented by Stallones and clearly illustrate the focus of heart disease in the eastern half of the country for both males and females. The use of state economic areas rather than states illustrates the different rates within the states, providing finer spatial gradation. The maps of per cent change (figures 3 and 5) indicate that the spatial pattern of mortality change differed from that of mortality rate, suggesting that those factors or characteristics which were responsible for geographic variation in the establishment of the rate of ischemic heart disease may not be the same as those related to its current decline. Kimm et al. (3) suggest that the onset of declining rates has varied both geographically and demographically. Our analysis suggests that the magnitude of the decline in heart disease mor-

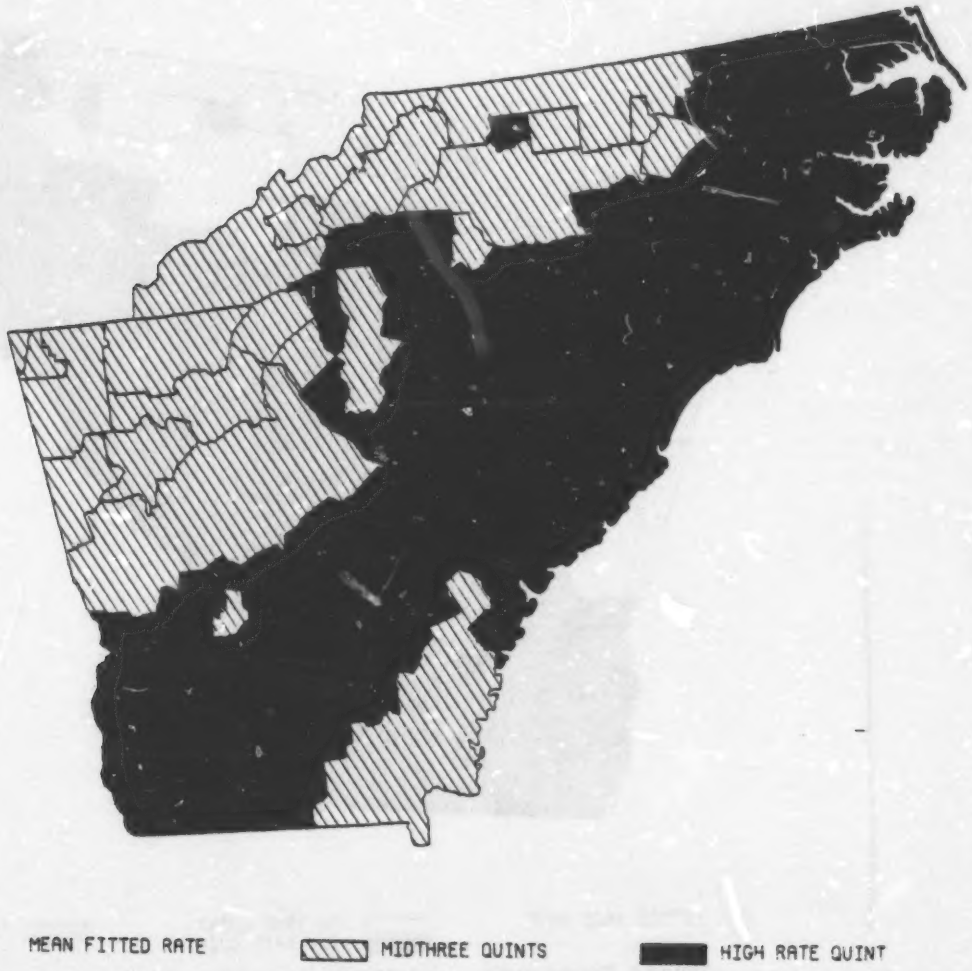


FIGURE 7. Fitted mortality rates, 1973, ischemic heart disease, white males aged 35–74 years, Southeast, by state economic area.

tality has also varied spatially and that the pattern of variation, while similar overall, differs for white males and females. The similarity of experience at the state economic area level between males and females for the mean rate of ischemic heart disease appears stronger than for per cent change, and this suggestion is partially supported by correlation coefficients (table 5). This may indicate that factors which influence the level of mortality for males and females are similar and so have few spatial differences, while change factors are largely gender-specific and do not vary together geographically. This may partially explain the difference in the rate-change correlation among males and females.

Analyses performed with the county as the unit of study have been reported by Hames and Sauer (22) and Keil et al. (2). Each of these reports compares metropolitan or urban counties to nonmetropolitan or rural counties.

Hames and Sauer investigated cardiovascular disease mortality for Georgia counties from 1968–1976 and found changes in mortality for counties but no change in the overall pattern of high and low rate areas

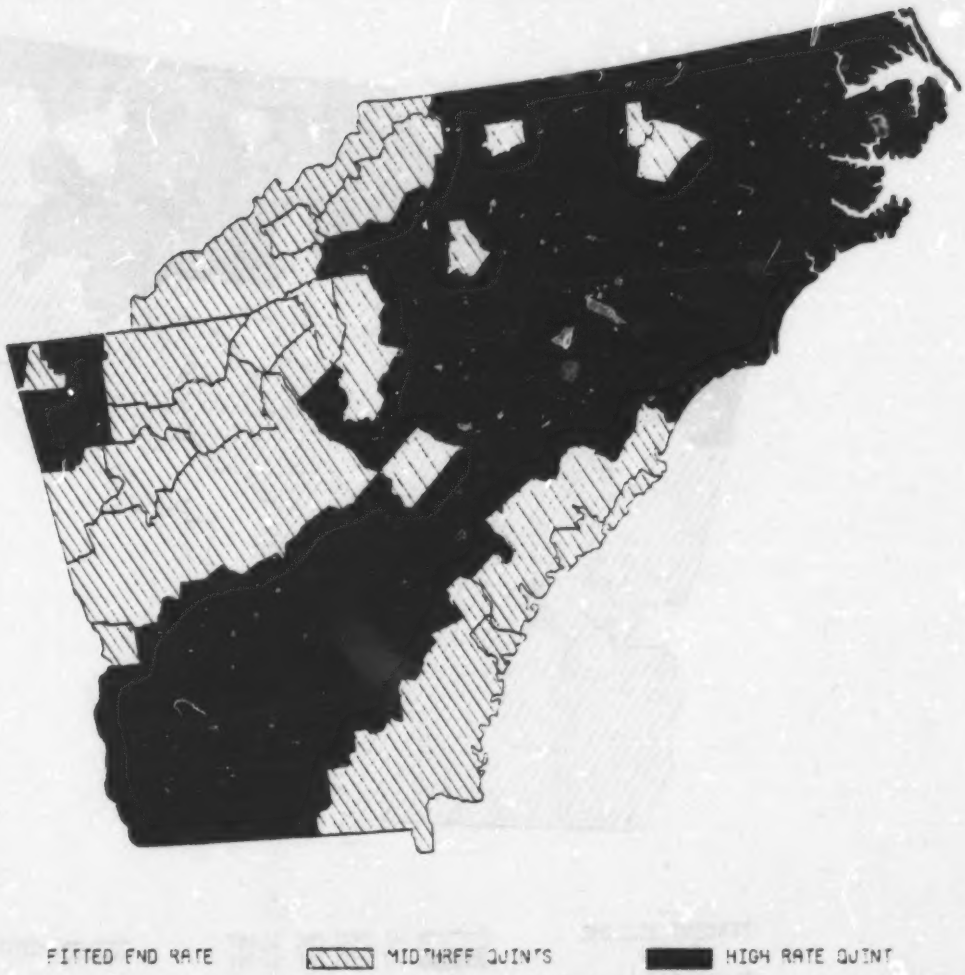


FIGURE 8. Fitted mortality rates, 1978, ischemic heart disease, white males aged 35–74 years, Southeast, by state economic area.

when compared with an earlier study from the 1950s. Examining two subperiods (1968–1972, 1973–1976), Hames and Sauer found that less than half of Georgia's metropolitan counties had decreases for the early period, yet all had declines for the later time. Among nonmetropolitan counties, nearly half had declines in the first period, yet over one third of the counties still had *increasing* rates for the later time.

Keil et al. (2) examined South Carolina heart disease mortality rates for 1968–1977, comparing a pair of urban counties, a pair of "semi-rural" counties (in the interior coastal plain noted for high cardiovascular disease mortality), and the entire state. For three three-year periods (1969–1971, 1972–1974, 1975–1977), ischemic heart disease rates in the coastal plain were consistently higher than those in the urban counties, whose rates, in turn, were higher than those for the state as a whole. In the first time period, declining rates were not evident in the urban counties and were experienced only by females in the coastal plain area; for the entire state, only white males *failed* to have declining heart disease rates. All groups for all three areas demonstrate re-

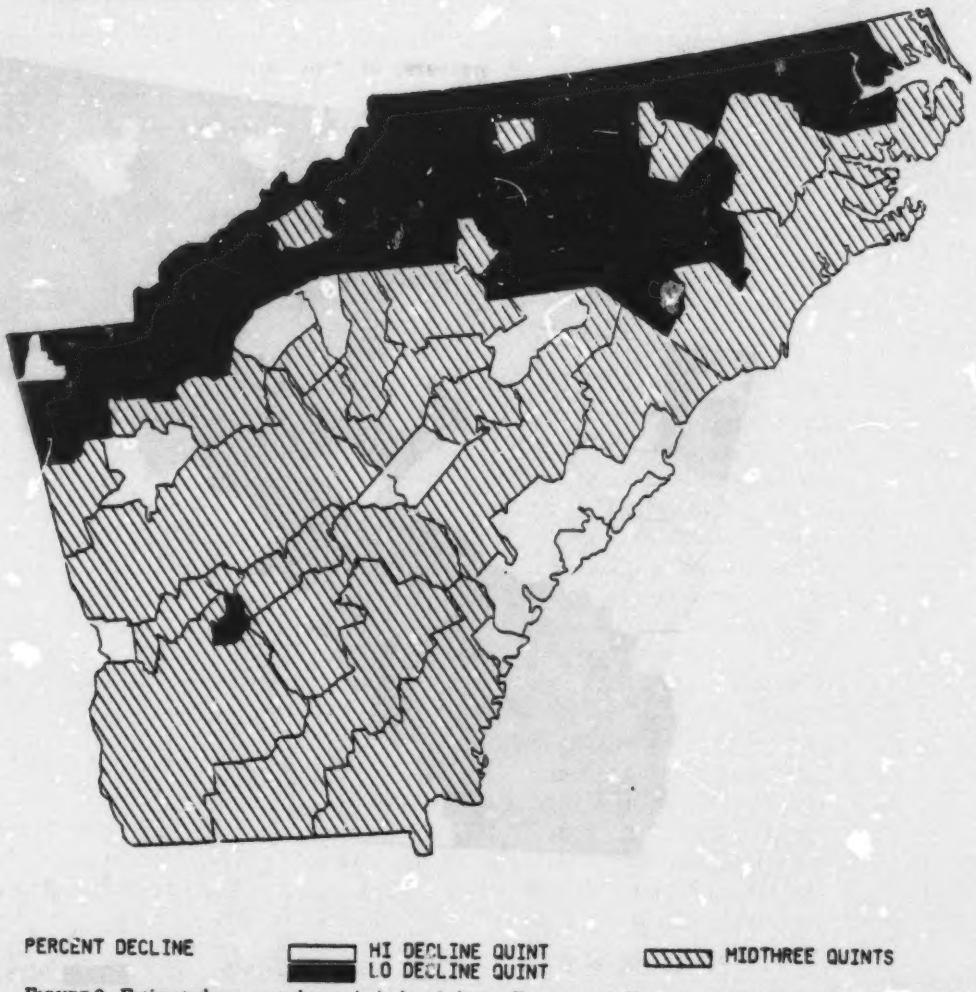


FIGURE 9. Estimated per cent change in ischemic heart disease mortality rates, 1968–1978, white males aged 35–74 years, Southeast, by state economic area.

markable declines for the later period. The results suggest that the ischemic heart disease decline for South Carolina may have been in force as early as 1969, yet for the coastal plains, only females benefited in the early period, while in an urban area, no evidence of the decline is found until 1972.

These investigators provide further evidence of spatial and demographic variation in declining heart disease mortality. Hames and Sauer (22) found variation in the onset of decline, with a greater proportion of metropolitan counties having declining rates than nonmetropolitan counties. Keil et al. (2) found a spatial rate differential and a difference in the onset of declining mortality, white females appearing to have some temporal advantage for declines in mortality over other groups. These results provide additional support for our choice of state economic areas, which employ a metropolitan/nonmetropolitan designation, as the unit of analysis. These units are a more appropriate choice of aggregation than states, which obscure metropolitan areas, and are more manageable, although per-

haps less accurate, than using counties and including additional data on measures of urbanization.

Thom and Kannel (23), in a review article on the decline in cardiovascular disease, summarized the current view of the decrease by stating, "For the first time, all age, race and sex groups experienced remarkably similar trends" and that, furthermore, the mortality decline pattern was "fairly uniform for virtually all geographic areas." They concluded, "In the absence of evidence, one can only speculate about causes by comparing the timing, extent and demographic patterns of these mortality trends with the timing, extent and pattern of trends" in other factors of interest.

Conclusions of demographic and geographic uniformity in declining cardiovascular disease mortality stated by Thom and Kannel (23) differ from the results of our study of heart disease mortality in the United States for the years 1968–1978. We found important differences by sex and marked spatial variation in ischemic heart disease and its components. Rates and per cent change for the United States confirm the well known male excess of mortality; male rates exceed female rates by two to one for all causes, all ischemic heart disease, and chronic ischemic heart disease, and by three to one for acute myocardial infarction. The male and female mortality declines are identical for all causes and acute myocardial infarction, somewhat greater for females for all ischemic heart disease, and markedly greater for females for chronic ischemic heart disease. For males, most of the decline in heart disease is attributable to declines in the acute component, while for females, substantial declines were found for both the acute and chronic portions. This is an important difference which may be due to diagnostic custom, different manifestations of heart disease in males and females, or a differential impact of the factors behind the decline. When the component analysis was conducted at the state economic area level, acute myocardial infarction rates declined, for both sexes, in nearly all areas. For chronic ischemic heart disease, female rates increased in one fourth of the areas, and male rates increased in half of the areas.

Our spatial examination of total ischemic heart disease, employing rates and change for state economic areas, demonstrated the better than twofold difference in rates, the marked west-to-east gradient of heart disease mortality, and evidence of apparent clustering by rate category. The rate maps indicate that virtually all high rate areas are located in the eastern half of the United States, and the vast majority of the low rate areas are found in the western half of the country.

Our analysis examined the per cent change in mortality rates for the study period and reported the variation in the magnitude of rate declines. While the range of declines for the middle three quintiles was relatively narrow, areas in the upper and lower quintiles were more dissimilar from those in the middle three, and there was visual evidence of clustering among high and low change areas. The overall patterns of the male and female change maps did not provide an indication of a national gradient similar to that found on the rate maps. This lack of similarity between spatial patterns of rate and change suggests the possibility that the factors most important for the level of heart disease mortality may not be the same as those having the greatest impact for the decline. Furthermore, statistical correlations and visual associations between rate and change suggest no consistent relationship. Specifically, white male and female groups residing in certain areas of the Northeast experienced high rates of heart disease mortality and low declines in those rates for the study period. Demographically similar groups residing in coastal areas of the Southeast also experienced high rates, but simultaneously benefited from large declines in the level of mortality. Our examination of the Southeast, reported here, clearly suggests this

spatial association between rate and change values. Whether this speaks to different factors operating to produce similar levels of mortality or similar factors differentially present to influence mortality reduction or to chance occurrences is not clear. What is clear is that these associations and questions about them are part of the changing patterns and trends in heart disease mortality. Our study provides new information on the magnitude and variation of the decline in heart disease mortality and points to some future research directions of potential importance.

In future reports, we will pursue these questions further and will also examine gender comparisons in greater detail, nonwhite patterns, age-specific trends, environmental factors, occupational and socioeconomic characteristics, and medical care and health services availability.

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